

On Scandium.

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(Abstract.)

Scandia is one of the rarest and least known of the recognised rare earths. It was discovered in 1879 by Nilson, who separated it, together with ytterbia, from erbia extracted from euxenite and gadolinite. Later in the same year Cleve extracted scandia from gadolinite, yttriotitanite, and keilhauite, and described the scandium sulphate, double sulphates, nitrate, oxalate, double oxalates, selenate, acetate, formate, oxide, and hydrate, and gave some of the chief reactions of the new body.

In the course of my 20 years' work on the fractionation of the rare earths I have repeatedly tested my products by examining their photographed spectra, using the dominant lines of the various elements as tests for their presence. Scandium has an extremely characteristic group of lines in its spectrum, situated between wave-lengths 3535.864 and 3651.983, the strongest being at 3613.984, midway between two strong iron lines. By using a part of the spectrum in which this occupies the centre of the photograph it is easy to see if scandium is present. Detecting the dominant line, the presence of scandium can be verified by reference to the other lines of the group.

Scandium I found in some of my fractions, but only in small quantities. A few years ago I commenced an examination of all the obtainable rare earth minerals, in order to see if any of them showed more than a trace of scandium. The minerals examined were:—

Æschynite.	Homolite.	Thalenite.
Allanite.	Keilhauite.	Thorianite.
Alvit.	Knopite.	Thorite.
Auerlite.	Koppite.	Thorogummite.
Baddeleite (Ceylon).	Lanthanite.	Tscheffkinite.
Bastnasite.	Monazite.	Tysonite.
Broggerite.	Mosandrite.	Urdite.
Cerite.	Orangite.	Wiikite.
Clevite.	Orthite.	Xenotime.
Columbite.	Polyerase.	Yttergarnet.
Cryptolite.	Pyrochlore.	Yttrialite.
Eudialite.	Rhabdophane.	Yttrocerite.
Euxenite.	Samarskite.	Yttrogummite.
Fergusonite (Ceylon).	Scheelite (Bohemia).	Yttrotantalite.
Fergusonite (Ytterby).	Scheelite (New Zealand).	Yttrotitanite.
Fluocerite.	Schorlomite.	Zirkelite (Ceylon, sp. gr. 5.0).
Gadolinite.	Sipylite.	Zirkelite (Ceylon, sp. gr. 4.42).
Hielmite.	Tantalite.	

Of the minerals examined, scandium was detected in auerlite, cerite, keilhauite, mosandrite, orangite, orthite, pyrochlore, thorianite, thorite, and wiikite, but while other minerals contained less than 0·01 per cent. of scandium, wiikite was found to contain more than one hundred times that amount.

Wiikite is a black amorphous mineral of specific gravity 4·85. Its hardness is 6. It is infusible before the blowpipe. It is imperfectly attacked by strong mineral acids, and breaks up easily when fused with potassium bisulphate. Heated to full redness in a silica tube, it gives off helium, water, and a distinct amount of sulphuretted hydrogen, followed by a white sublimate. The mineral begins to crack at a temperature a little below redness, and at the approach of redness gas is evolved with almost explosive violence, the mineral breaking up and flying about the tube. A fragment so treated examined under the microscope shows the surface covered with glistening points. With a high power these points are resolved into a mass of minute cubes, curiously regular in form and appearance. Heating drives off 5·83 per cent. of its weight; 5·82 of the loss is water and acid vapour, the difference, 0·01 per cent., consisting chiefly of helium, with a little hydrogen, carbon dioxide, and a mere trace of neon.

Containing so many bodies, the exact separation of which one from the other is not known, it is at present impossible to give an accurate and complete analysis of wiikite. The following is considered to be a fair approximation to its composition:—

Tantalic acid with some niobic acid	15·91
Titanic acid and zirconia.....	23·36
Earths of the cerium group	2·55
Earths of the yttrium group	7·64
Scandia.....	1·17
Thoria	5·51
Ferrous oxide	15·52
Uranic oxide	3·56
Silica	16·98
Water and gases	5·83
Calcium, manganese, tin, sulphur, etc., unestimated	1·97
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	100·00

After the crude earths, chiefly yttria, ytterbia, and scandia, have been separated from the mineral, they are "fractionated" by methods described in the paper. Towards the end of the fractionation the chief impurity is

ytterbium. Fortunately the very strong dominant line of the ytterbium spectrum, wave-length 3694·344, occurs at a vacant part of the scandium spectrum, and near the characteristic group of scandium. A sample of scandia is not taken as satisfactory if the least trace of this line is seen on an over-exposed spectrum of scandium, and if the actomic weight is higher than 44·1. The atomic weight of ytterbium being 173, a very little of it as an impurity raises the atomic weight of scandium.

I have prepared and analysed the following compounds of scandium :—

Scandium hydroxide, $\text{Sc}_2\text{O}_3 \cdot 3\text{H}_2\text{O} = \text{Sc}(\text{OH})_3$.

Scandium carbonate, $\text{Sc}_2(\text{CO}_3)_3 \cdot 12\text{H}_2\text{O}$.

Hydrated scandium chlorides, $\text{Sc}_2\text{Cl}_6 \cdot 12\text{H}_2\text{O} = \text{Sc}_2\text{O}_3 \cdot 6\text{HCl} \cdot 9\text{H}_2\text{O}$,
 $\text{Sc}_2\text{Cl}_6 \cdot 3\text{H}_2\text{O} = \text{Sc}_2\text{O}_3 + 6\text{HCl}$.

Hydrated scandium bromides, $\text{Sc}_2\text{Br}_6 \cdot 12\text{H}_2\text{O}$, $\text{Sc}_2\text{Br}_6 \cdot 3\text{H}_2\text{O} = \text{Sc}_2\text{O}_3 \cdot 6\text{HBr}$.

Scandium chlorate.

Scandium perchlorate.

Scandium bromate.

Scandium sulphates, $\text{Sc}_2(\text{SO}_4)_3 \cdot 6\text{H}_2\text{O}$, $\text{Sc}_2(\text{SO}_4)_3 \cdot 5\text{H}_2\text{O}$.

Anhydrous scandium sulphate, $\text{Sc}_2(\text{SO}_4)_3$.

Basic scandium sulphate, $\text{Sc}_2\text{O}(\text{SO}_4)_2$.

Scandium and potassium double sulphate, $3\text{K}_2\text{SO}_4 \cdot \text{Sc}_2(\text{SO}_4)_3$.

Scandium selenates, $\text{Sc}_2(\text{SeO}_4)_3 \cdot 8\text{H}_2\text{O}$, $\text{Sc}_2(\text{SeO}_4)_3 \cdot 2\text{H}_2\text{O}$.

Scandium nitrates, $\text{Sc}(\text{NO}_3)_3 \cdot 4\text{H}_2\text{O}$, $\text{Sc}(\text{NO}_3)_3$, $\text{ScOH}(\text{NO}_3)_2\text{H}_2\text{O}$, $\text{Sc}_2\text{O}(\text{NO}_3)_4$.

Scandium formate, $(\text{HCOO})_2\text{ScOH} \cdot \text{H}_2\text{O}$.

Scandium acetate, $(\text{CH}_3\text{COO})_2\text{ScOH} \cdot 2\text{H}_2\text{O}$.

Scandium propionate, $(\text{C}_2\text{H}_5\text{COO})_2\text{ScOH}$.

Scandium butyrate, $(\text{CH}_3\text{CH}_2\text{CH}_2\text{COO})_2\text{ScHO}$.

Scandium iso-butyrate, $\left(\begin{smallmatrix} \text{CH}_3 & > \text{CH} \cdot \text{COO} \\ & \text{CH}_3 \end{smallmatrix}\right)_2\text{ScOH} \cdot 2\text{H}_2\text{O}$.

Scandium iso-valerate, $(\text{C}_4\text{H}_9\text{COO})_2\text{ScOH} \cdot 2\text{H}_2\text{O}$.

Scandium oxalates, $\text{Sc}_2(\text{C}_2\text{O}_4)_3 \cdot 5\text{H}_2\text{O}$, $\text{Sc}_2(\text{C}_2\text{O}_4)_3 \cdot 3\text{H}_2\text{O}$, $\text{Sc}_2(\text{C}_2\text{O}_4)_3 \cdot 2\text{H}_2\text{O}$,
 $\text{Sc}_2(\text{C}_2\text{O}_4)_2 \cdot \text{H}_2\text{O}$.

Scandium picrates, $[\text{C}_6\text{H}_2(\text{NO}_2)_3\text{O}]_2\text{ScOH} \cdot 14\text{H}_2\text{O}$,
 $[\text{C}_6\text{H}_2(\text{NO}_2)_3\text{O}]_2\text{ScOH} \cdot 5\text{H}_2\text{O}$.

Scandium pyromellitate.

Scandium camphorate.